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Renormalization of the Abelian Higgs-Kibble Model

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Abstract. This article is devoted to the perturbative renormalization of the abelian Higgs-Kibble model, within the class of renormalizable gauges which are odd under charge conjugation. The Bogoliubov Parasiuk Hepp-Zimmermann renormalization scheme is used throughout, including the renormalized action principle proved by Lowenstein and Lam. The whole study is based on the fulfillment to all orders of perturbation theory of the Slavnov identities which express the invariance of the Lagrangian under a supergauge type family of non-linear transformations involving the Faddeev-Popov ghosts. Direct combinatorial proofs are given of the gauge independence and unitarity of the physical S operator. Their simplicity relies both on a systematic use of the Slavnov identities as well as suitable normalization conditions which allow to perform all mass renormalizations, including those pertaining to the ghosts, so that the theory can be given a setting within a fixed Fock space. Some simple gauge independent local operators are constructed.

Introduction

The latest achievements on the renormalization of Lagrangian models involving gauge fields, mostly due to t'Hooft, Lee, Veltman, Zinn-Justin [1], were primarily based on the use of a gauge invariant regularization procedure, the most popular of which being the so called dimensional regularization [2]. The gauge structure could thus conveniently be respected by fulfilling the so called Slavnov identities [3] through the renormalization procedure. There resulted finite Green's functions which could not however be directly given an interpretation relevant to an operator theory in some Fock space, were it be in a perturbative sense, because of the lack of the finite mass renormalizations which would have been necessary for this purpose. As will be seen here, an operator interpretation is quite convenient for any discussion involving asymptotic concepts concerning e.g. the unitarity of the S operator, the construction of gauge invariant local operators etc.

We shall treat here the simplest model involving gauge fields in which no infrared problem occurs, namely the abelian Higgs-Kibble model [4] within the class of gauges advocated by t'Hooft. The algebraic complications which occur in the non abelian cases are deferred to later publications.

We shall make full use of the combinatiorial knowledge or renormalized perturbation theory that has been acquired through the work of Zimmermann [5] (effective Lagrangians, normal products, Wilson expansions), Lowenstein [6] and

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